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Original Article

REPAIR OF THE MANDIBULAR NERVE BY AUTOGENOUS GRAFTING AFTER ABLATIVE SURGERY OF THE MANDIBLE

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Abstract

In this paper, we introduce our original method of autologous nerve grafting for substitution of the mandibular nerve after mandibular resection in three subjects. The lateral cutaneous nerve of the forearm served as a donor nerve, and the graft was imbedded microsurgically at the junctures using an epineurial nerve suture technique. Oversized grafts were chosen in order to insert them without tension in a space between the stumps of the recipient nerve and the regeneration zone of the bone. In all three subjects, sensibility of the lower lip and chin recovered completely after about ten months.

Key words: Inferior alveolar nerve—Resection of the mandible—Lateral cutaneous nerve of forearm

INTRODUCTION

The inferior alveolar nerve is a sensory nerve that runs through the mandible and controls the sensations of the gingiva, teeth, and mental skin. In patients for whom mandibulectomy due to various lesions in the mandible is unavoidable, this nerve is often excised or amputated, which leads to functional disorders such as salivation, burns, or leakage of food and drinks caused by semi-permanent sensory disability in the lower lips or chin. This type of sensory neuroparalysis has been considered to be unavoidable due to the nature of mandibulectomy, and these consequences have therefore been grudgingly accepted.

With advancements in reconstructive surgery, microsurgery, neurosuturing, and autografts have produced favorable results[7,8]. Ever since the introduction of microsurgical technology in 1977, our department has devoted our efforts to recovering sensory functions by actively practicing nerve restoration to treat these symptoms.

In this study, a new type of nerve repair surgery is developed and introduced. Recently, autologous grafting of nerves such as the great auricular nerve or sural nerve has been used in patients with malignant tumors;

the great auricular nerve is not used because it is part of the neck dissection area. Use of the sural nerve leaves surgical scars on the sura of the patient and causes sensory loss in the dorsum of the foot. Therefore, a lateral cutaneous nerve of the forearm is used as a donor nerve when reconstructive surgery using the forearm flap is applied.

This paper introduces a new application and method of nerve repair surgery and reports results of the evaluation of sensory functions after operation.

Fig. 1 Oral findings in a stage IV squamous cell carcinoma of the lower gingiva

MATERIALS AND METHODS

We treated three patients who had squamous cell carcinoma of the lower gingiva by radical neck dissection, followed by tumor resection and immediate reconstruction of the AO plate. The forearm flap was used in the reconstruction following extensive resection of the gingiva and the floor of the mouth. Following revascularization of the flap, the lateral cutaneous nerve was severed. The length required for grafting was determined and dissected from the surrounding tissue. The proximal and distal ends of the inferior alveolar nerve were trimmed with the aid of a surgical microscope, and tissue surrounding the epineurium was removed. The lateral cutaneous nerve was then excised 20% longer than the resected inferior alveolar nerve to avoid any tension following grafting. Nerve suturing was performed using the epineurial technique under a surgical microscope. A 9-0 polyglycolic acid suture attached to an atraumatic needle was used for this procedure.

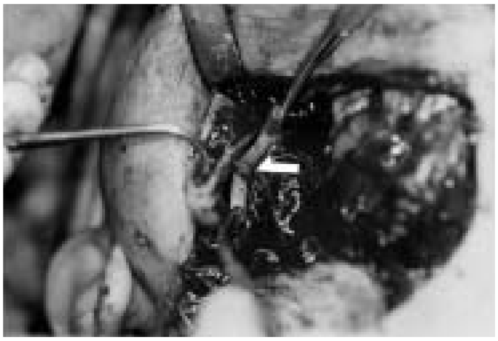

Fig. 2 Amputation of the nerve and swing of the mandible. The use of a flexible strip of gauze is very effective in the delivery of the nerve through the inferior alveolar canal (arrow).

Fig. 3 A mandibulectomy is performed at the proximal (arrow ⇧) and distal (arrow ⬆) sides of the mandible.

1. Operative technique

The operative technique for a representative case is described below.

The subject was a 59 year old male diagnosed with squamous cell carcinoma in the right lower gingiva (Fig. 1). We removed the cortical bone from the mental foramen of the proximal side to expose the inferior alveolar nerve. After knotting the proximal end of the nerve, the lesion was clearly revealed, and the mandibular bone was amputated (shown by an arrow). We wrapped the inferior alveolar nerve with rubber to avoid damaging and pulling its stump (Fig. 2). Then we conducted a mandibulectomy on the distal side of the

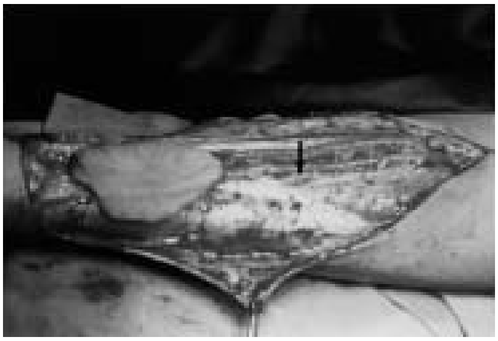

Fig. 4 Left forearm flap (arrow ⇧) before transfer. The proximal and lateral cutaneous nerves of the forearm have been isolated (arrow ⬆).

Fig. 5 The epineurial nerve suture. We usually employ five stitches for each suture section with 9-0 Dexon thread. A cable suture was applied in order to tie 2 or 3 nerves together (arrow).

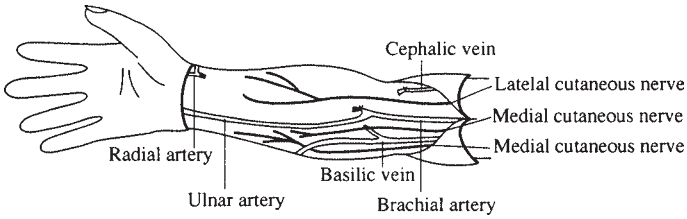

Fig. 6 A representative anatomical pattern outlined on the volar aspect of the forearm

mandible (Fig. 3 shown by an arrow). The tumor was removed simultaneously with radical neck dissection. Reconstruction of the extensive defect was performed using a left forearm flap shown by an arrow in Fig. 4.

Microvascular anastomoses were performed in end-to-end fashion between the left cervical artery and the left external jugular vein. The cutaneous nerve of the forearm used as donor nerve is also shown in Fig. 4. This nerve was sacrificed; therefore, there was no need to perform any other surgical operations in other parts of the body. The lateral cutaneous nerves of the forearm were anastomosed to transected branches of the inferior alveolar nerve. The cutaneous nerve of the forearm in this case was long and thin. Under these circumstances, a cable suture can be applied in order to tie 2 or 3 nerves together (Fig. 5).

The anatomic view of the forearm diagrams the medial and lateral sites of the cutaneous nerve under the skin[10] (Fig. 6).

The forearm flap to transfer the skin of the volar aspect of the forearm extended from the distal portion of the upper arm to the level of the flexor retinaculum. The forearm flap was positioned on the volar aspect of the forearm to cover the course of the radial artery and one of major superficial veins of the forearm. The medial and lateral cutaneous nerves were long; ones 2 to 3 mm in diameter sections could be isolated from the subcutaneous tissue near the proximal portion of the forearm skin paddle. These nerves usually run along the superficial veins and can be dissected to obtain an adequate length for anastomosis to recipient nerves.

2. Evaluation of sensory function recovery

Semmes-Weinstein monofilaments, which are an advanced version of the Von Frey filament, were used to test the touch sense. The nylon fibers were pushed against the mental skin until the patient was able to sense the pressure and determine its intensity. The

Table 1 Patient profiles

Age	Sex	Diagnosis	Location	Excision of mandible	Follow-up
59	M	SCC	left gingiva	full-thickness	15 months
54	M	SCC	right gingiva	full-thickness	14 months
57	M	SCC	left gingiva	full-thickness	10 months

SCC; squamous cell carcinoma

initial nylon fiber was the finest and was used to stimulate a specific point at the center of the tested mental skin. The testing pressure was increased until the patient was able to detect it.

In order to evaluate the sensory function, nine cases of inferior alveolar nerve amputation without a nerve transplant were compared.

The shortest post-surgical evaluation lasted for one month while the longest lasted for twelve months.

Fig. 7 Restoring the mandible using an mandibular reconstruction plate

RESULTS

The treatments of the three cases in our study are summarized in Table 1. The patients (all males, age range 54–59 years) had squamous cell carcinoma of the lower gingiva. All had undergone an amputation of the mandible. An AO mandibular reconstruction plate was used for mandibular reconstruction (Fig. 7). Epineural suturing of nerve was performed on all three patients.

The recovery courses of sensation two to ten months after surgery in the chins of the three patients who underwent autogenous nerve grafting are shown in Fig. 8. Initially, patients complained of hyperesthesia-like dysesthesia or paresthesia in the mental area. Almost simultaneously, pain sensibility began to be restored. Touch sensibility began to return slightly later than pain. Ten months after surgery, pain sensibility was restored and touch sensibility was present in all patients. One year after surgery, both sensibilities were restored in all patients. Fig. 8 shows the touch sensory range after the surgery. The non-graft group showed the highest measurement values of the SW test. Recovery conditions were unvaried in patients who did not receive a transplant. From these results, it was confirmed that the recovery proceeded properly.

DISCUSSION

The purpose of nerve repair surgery is to regenerate axons from the remaining mandible to the peripheral skin without preventing the neuro-healing process. The neuroautograft procedure has been practiced extensively since Mayo-Robinson's success. In the oral and maxillofacial region, Hausamen *et al.* transplanted a sural nerve graft 20 cm long after excising an ameloblastoma in 1973[2]. In Japan, Noma *et al.* reported a successful great auricular nerve transplant after reconstruction with an iliac bone graft and confirmed that the bone formation mechanism did not affect the grafted nerves[4].

When the extensive defects after ablative surgery are reconstructed with a forearm flap after segmental mandibular resection is per-

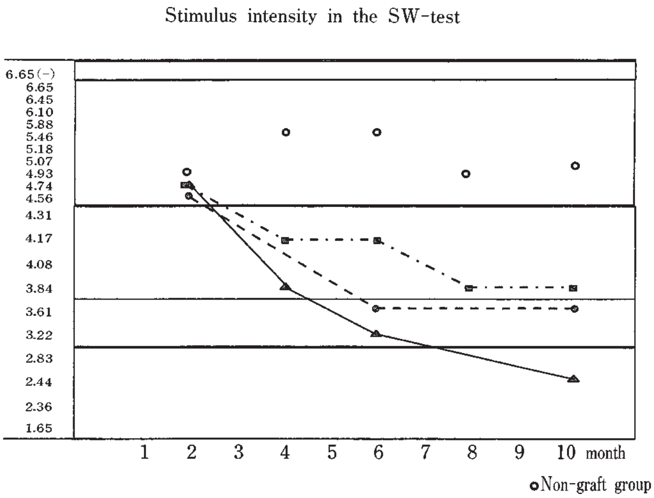

Fig. 8 The diagram shows recovery courses after the surgery evaluated by SW-test. From these results, it was confirmed that the recovery proceeded properly. The non-graft group shows the highest values in the SW-test.

formed, inferior alveolar nerve repair is also necessary. In such cases, the lateral branch of the forearm cutaneous nerve is often selected for grafting. The nerve which innervates the forearm is sacrificed, and therefore, there is no need to perform any other surgical operations in other parts of the body. The forearm lateral cutaneous nerve has many branches that form a nerve plexus. If a part of the nerve is used as a graft, damage is limited to some extent, and new branches will regenerate from the remaining main branches.

Clinically, many patients regain sensation in the dorsal hand and fingers in six months to one year after surgery. Unless the main branches of nerves such as the radical nerve is damaged, the sensory damage is temporary, and their sensation is recovered.

Such nerve grafting should be effective in enabling functional recovery. Peripheral nerve fibers have a good regenerative capacity. However, when the cut ends are left in connective tissue, the regenerating axons are rapidly caught within the scar. The aims of nerve grafting are to surgically maintain continuity of the Schwann's sheath and to lead the regenerating axon from the proximal cut end to the distal cut end. The principal requirement for success in nerve grafting is to reduce scar formation as much as possible at the site of nerve connection and to expedite passage of the regenerating axon through the grafted nerve. Many basic and clinical studies have developed epineurial nerve grafting into a successful technique[1,2,4].

Using animals, we have sutured the transected inferior alveolar nerve, and observed the changes in the sensory receptors[5,6]. When the nerve is repaired, a regenerated axon is extended along the nerve stumps. The basal lamina scaffolds of Schmann cells derived from the nerve grafting are an effective pathway not only for the initial axonal elongation to the skin but also for the maintenance and maturation of regenerating axon[3]. In addition to supporting neuronal survival, neurotrophins and nerve growth factors produced in the target tissue are involved in maintaining the sensitivity of touch receptors within the skin[9]. Therefore, there is the possibility that higher sensory functions may be restored. When the nerve is not repaired, the axonal elongation to the target tissue is unlikely. Accordingly, the restored sensation in the graft group will differ in quality from that in the non-graft group.

Microsurgery, including nerve repair surgery, is performed to improve the life quality of patients. Assuming that the lesions are correctly treated and the most appropriate surgical method is selected, nerve grafting is very useful for the recovery of sensory nerve functions after mandibulectomy.

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